

REMARKS

Claims 1 through 5 and 7 through 63 are currently pending in the application, claim 63 being newly added with this amendment.

Claim 6 has been canceled.

Claims 33 through 57 are withdrawn from consideration in the Office Action as being directed to a non-elected invention.

Claims 1 through 32 and 58 through 62 currently stand rejected.

Claims 3, 8, 9, 61 and 62 have been amended.

This amendment is in response to the Office Action of April 19, 2002.

After carefully considering the cited prior art, the rejections, and the Examiner's comments, Applicant has amended the claimed invention to clearly distinguish over the cited prior art.

Claim Objections

Claims 8 and 61 were objected to due to informalities in the claim language. The claims have been amended to properly spell "glycidoxypyltrimethoxysilane" as suggested by the Examiner. Paragraphs 10 and 33 of the specification have also been amended to correct this spelling error.

35 U.S.C. § 101 and 35 U.S.C. § 112 Rejections

Claims 3, 61 and 62 were rejected under 35 U.S.C. § 101 because the disclosed invention is inoperative and therefore lacks utility.

Claims 3, 61 and 62 were rejected under 35 U.S.C. § 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that Applicant, at the time the application was filed, had possession of the claimed invention.

Claims 3, 9, 61 and 62 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicant regards as the invention.

Regarding claims 3, 61 and 62, the rejection states that the limitations of "said wetting agent layer includes a layer of silane", "said wetting agent layer comprises one of silane," and "applying a silane layer" render the claims inoperative and indefinite. According to the Examiner, this is because silane has a melting point of -185°C and would be a gas in the disclosed process, making it inoperative as the claimed wetting agent layer. Applicant respectfully submits that this is an improper interpretation of the term "silane" and that the specification clearly and sufficiently describes the invention in such a manner as to support the claims.

The term "silane" can describe any of various compounds of hydrogen and silicon that have the general formula $\text{Si}_n\text{H}_{2n+2}$. Based on the cited melting point of -185°C and the indication of a gaseous state, Applicant assumes the Examiner is referring to a silane gas having this formula, which is well known in the semiconductor industry for use in deposition of epitaxial silicon, amorphous silicon and silicon based dielectrics.

However, it is also well known in the art that the term "silane" refers to a wide variety of silane-based compounds used as surface modifying agents to improve coupling and adhesion with other materials. Glycidoxypropyltrimethoxysilane and ethyltrimethoxysilane are two such compounds which are provided as examples in Applicant's disclosure. Silanes of this type are in liquid form at ambient application temperatures. This is supported in the specification, which indicates glycidoxypropyltrimethoxysilane has a boiling point of 290°C and ethyltrimethoxysilane has a boiling point of 310°C (see specification, page 10, paragraph 33). The specification also indicates any silane-based material may be used so long as any substantial degradation thereof is minimal during any solder reflow or curing process for bumps 24, or during any burn-in or testing process, so the silane layer promotes a sufficient wetting effect (see specification, page 10, paragraph 33).

Accordingly, Applicant respectfully submits the specification contains sufficient written description, and that claims 3, 61 and 62 are allowable under the provisions of 35 U.S.C. § 101 and 35 U.S.C. § 112. Nonetheless, in order to eliminate any confusion, claims 3, 61 and 62 have been amended to replace "silane" with "silane-based material".

Regarding the 35 U.S.C. § 112 rejection of claim 9, the terms "said active surface" and "said top surface" have been replaced with terminology finding antecedent basis in claim 1.

35 U.S.C. § 102(e) Anticipation Rejections

Claims 1, 2, 4 through 7, 9 through 12, 15, 22 and 58 through 60 were rejected under 35 U.S.C. § 102(e) as being anticipated by Dery et al. (United States Patent 6,074,895).

Applicant submits that a claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. *Verdegaal Brothers v. Union Oil Co. of California*, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). The identical invention must be shown in as complete detail as is contained in the claim. *Richardson v. Suzuki Motor Co.*, 9 USPQ2d 1913, 1920 (Fed. Cir. 1989).

Dery et al. describes a method of forming a flip-chip assembly. A flip-chip 110 with a passivation layer 111 of polyimide or other material is attached to a chip carrier 120 which may have an epoxy resin solder mask surface 124 with inorganic filler particles (see col. 3, lines 46-57 and col. 4, lines 11-15). A gaseous plasma is used to treat the chip 110 in order to oxidize and microroughen the surface of passivation layer 111 (see col. 4, lines 1-8). The surface 124 of chip carrier 120 may also be roughened by the gaseous plasma or by mechanical means (see col. 4, lines 36-60). An encapsulant material 140 is then used to underfill the space between flip-chip 110 and chip carrier 120. The plasma treatment is believed to enhance adhesion between the filler and the chip surface and chip carrier (see col. 1, lines 21-34).

Independent claims 1, 10 and 58 of the present application recite an element of the invention calling for "applying a wetting agent layer" to one of a semiconductor surface and a

substrate surface. Applicant respectfully submits Dery et al. fails to expressly or inherently anticipate "applying a wetting agent layer" under 35 U.S.C. § 102. Instead, Dery et al. uses a gaseous plasma to chemically and physically alter existing chip passivation layer 111 and chip carrier surface 124 to improve adhesion and reduce the incidence of delamination (see col. 2, lines 51-64). There is no discussion whatsoever of applying a layer of wetting agent to any of the chip or substrate surfaces. Accordingly, Applicant respectfully submits claims 1, 10 and 58 are allowable over Dery et al. under 35 U.S.C. § 102(e). Claims 2, 4 through 7, 9, 11, 12, 15, 22, 59 and 60 are allowable, among other reasons, as depending from claims 1, 10 and 58.

Furthermore, Dery et al. fails to anticipate under 35 U.S.C. § 102 the claim 4 and claim 59 limitation "applying said wetting agent layer comprises any one of a dispensing method, a brushing method, and a spraying method", the claim 7 limitation "wherein said wetting agent layer comprises a plurality of layers", and the claim 9 limitation "applying said wetting agent layer comprises providing a material for increasing the surface tension to one of said surface of said semiconductor device and said surface of said substrate". Dery et al. simply modifies an existing passivation layer and a chip carrier surface.

35 U.S.C. § 103(a) Obviousness Rejections

Applicant further submits that to establish a *prima facie* case of obviousness under 35 U.S.C. § 103 three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Third, the cited prior art reference must teach or suggest all of the claim limitations. Furthermore, the suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on Applicant's disclosure.

Claims 8 and 61 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Dery et al. as applied to claims 1, 2, 4 through 7, 9 through 12, 15, 22 and 58 through 60 and further in

combination with Plueddemann (United States Patent 4,231,910). Applicant respectfully submits this combination fails to establish a *prima facie* case of obviousness under 35 U.S.C. § 103.

Plueddemann teaches a primer composition for improving adhesion between a solid substrate and a thermoplastic. The composition consists essentially of 1 to 25 weight percent of an organosilicon compound selected from a group of silane compounds or partial hydrolyzates thereof and 75 to 99 weight percent of an alkoxymethyltriazine (see col. 2, lines 5-17). There is nothing in the cited references or from the knowledge generally available in the art that would motivate one of ordinary skill to combine the teachings of Plueddemann with the invention of Dery et al.

Dery et al. is directed to semiconductor manufacturing, while Plueddemann is drawn to forming a specific chemical composition. Plueddemann makes no mention of applying the inventive composition to a semiconductor process such as that in Dery et al. It was asserted that since both processes are drawn to improving adhesion of a plastic, it would be obvious to combine the two. However, "The mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification. *In re Gordon*, 733 F.2d at 902, 221 USPQ at 1127" (Fed. Cir. 1984) (at 1783). There is nothing in either of the references to indicate using the composition of Plueddemann in place of, or in combination with, the gaseous plasma of Dery et al. would provide any desirable improvement. In fact, there is no reasonable expectation that this modification would be successful. Plueddemann teaches a composition for improving adhesion between a *solid substrate* and a *thermoplastic*. Plueddemann does not contemplate adhering a liquid underfill encapsulant or adhering to an epoxy resin solder mask such as those described in Dery et al. At best, the combination would be obvious to try, which does not fulfill the standards for establishing a *prima facie* case for an obviousness type rejection under 35 U.S.C. § 103. Applicant therefore respectfully submits the combination is an attempt to piece together the subject matter required by the claims which could only be motivated by the benefit of hindsight provided solely by Applicant's own disclosure.

Accordingly, Applicant respectfully submits a *prima facie* case of obviousness has not been established, and claims 8 and 61 are allowable under 35 U.S.C. § 103(a).

Claims 13, 14, 16 through 21 and 23 through 30 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Dery et al. as applied to claims 1, 2, 4 through 7, 9 through 12, 15, 22 and 58 through 60 supra, and further in combination with Akram et al. (United States Patent 5,766,982).

Akram et al. teaches an apparatus and method for underfilling an area between a semiconductor substrate 10 and a flip-chip 12 (see col. 2, lines 52-54). Akram teaches that underfilling may be accomplished by filling from an opening 60 near the center of substrate 10, while the substrate and semiconductor assembly is inclined, and with the assistance of a vibrating device 48 (see col. 2, lines 60-64, col. 5, lines 56-67 and col. 6, lines 34-61).

There is no motivation to combine the teachings of Dery et al. with Akram et al. to establish a *prima facie* case of obviousness under 35 U.S.C. § 103 because the references teach away from one another. Akram et al. advocates a method which is cost effective and utilizes standard substrates (see col. 2, lines 46-49). Further, Akram et al. teaches away from underfilling processes that require additional equipment or specialized substrates (see col. 2, lines 32-42). Dery et al., on the other hand, teaches that the passivation layer 111 and substrate surface 124, must be chemically and physically modified with a gaseous plasma. Therefore, Dery et al. requires a plasma chamber (see col. 1, lines 57-63). Additional equipment is required in order to achieve the process of Dery et al. Applicant respectfully submits that it "is improper to combine references where the references teach away from their combination." M.P.E.P. § 2145(X)(D)(2) (citing *In re Grasselli*, 713 F.2d 731, 743, 218 U.S.P.Q. 769, 779 (Fed. Cir. 1983)).

The cited references, alone or in combination, also fail to teach or suggest all of the claim limitations to establish a *prima facie* case of obviousness under 35 U.S.C. § 103. As discussed above, Dery et al. does not teach the limitation of "applying a wetting agent layer" recited in independent claims 1 and 10. Instead, Dery et al. uses a gaseous plasma to chemically and physically alter the existing chip passivation layer and chip carrier surface. Akram et al. does not

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involve any kind of wetting or adhesion improvement, and its combination with Dery et al. does not overcome the deficient limitation of "applying a wetting agent layer". Claims 13, 14, 16 through 21 and 23 through 30 depend from independent claims 1 and 10. If an independent claim is nonobvious under 35 U.S.C. 103, then any claim depending therefrom is nonobvious. *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988).

Accordingly, Applicant respectfully submits the cited references fail to establish a *prima facie* case of obviousness, and claims 13, 14, 16 through 21 and 23 through 30 are allowable under 35 U.S.C. § 103(a).

Claims 31 and 32 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Dery et al. as applied to claims 1, 2, 4 through 7, 9 through 12, 15, 22 and 58 through 60 supra, and further in view of Banerji et al. (United States Patent 5,203,076).

Claims 31 and 32 depend from independent claim 10 which recites the limitation of "applying a wetting agent layer". For the same reasons as described above, neither Dery et al. nor Banerji et al. teach or suggest this claim limitation. Claims 31 and 32 are therefore allowable under 35 U.S.C. § 103(a), among other reasons, as depending from claim 10.

Applicant submits that claims 1 through 32 and 58 through 62 are clearly allowable over the cited prior art for the reasons set forth hereinabove.

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Applicant requests the allowance of claims 1 through 5, 7 through 32, and 58 through 63 and the case passed for issue.

Respectfully submitted,



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Enclosure: Version with Markings to Show Changes Made

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APPENDIX A

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

[0010] The present invention relates to a method and apparatus for underfilling the gap between a bumped or raised semiconductor device and a substrate. The present invention is directed to a method and apparatus for filling the gap between a semiconductor die and a substrate using underfill material where the semiconductor die is electrically and mechanically connected to the substrate. The method and apparatus includes the use of a wetting agent on at least a portion of the surface of the semiconductor die forming a portion of the gap between the semiconductor die and a substrate to which it is mounted and/or a wetting agent on at least a portion of the substrate forming a portion of the gap to increase the surface tension between the underfill material and the surface of the semiconductor die and/or the substrate. One embodiment of the present invention includes a layer of silane as a wetting agent on at least a portion of the active surface of the semiconductor die and/or a layer of silane on at least a portion of the upper surface of the substrate to which the semiconductor die is mounted, each layer of silane increasing the surface tension thereon, the increased surface tension allowing the underfill material to fill the gap between the semiconductor die and the substrate via capillary action forces in a lesser length of time. Various wetting agents may be used according to the present invention, such as [glycidoxypropyltinethoxysilane] glycidoxypropyltrimethoxysilane and ethyltrimethoxysilane.

[0033] In the present invention, prior to connecting the semiconductor die 12 to the circuits and/or contact pads on the upper surface 18 of the substrate 10, a wetting agent layer 2, such as a silane layer 2, is formed on the top surface 18 of substrate 10 and/or the active surface 20 of the semiconductor die 12. The wetting agent layer 2, such as a silane layer 2, can be formed thereon by any suitable spray method, brush application method, and/or a dispense

method, although spraying a silane layer 2 as a wetting agent layer is the preferable method in order to provide a substantial uniform layer thereon. The silane layer 2 is most preferably formed as a monolayer thickness but may be formed as one or more multiple layers or formed in addition to other layers promoting a wetting effect on the surface of either the upper surface 18 of the substrate 10, the active surface 20 of the semiconductor die 12, or both. The silane layer 2 may be provided to the surface of the semiconductor die 12 while in its wafer form prior to or after burn-in testing, or after the wafer has been diced into multiple individual dice or an individual die. As to the substrate 10, the silane layer 2 may be provided thereon at any stage prior to the semiconductor die 12 being mounted thereto. In addition, the silane layer 2 may be comprised of any silane-based material, i.e., [glycidoxypropyltrimethoxysilane] glycidoxypropyltrimethoxysilane (b.p. 290°C) and Ethyltrimethoxysilane (b.p. 310°C), so long as any substantial degradation thereof during any solder reflow process or curing process of the bumps 24 or any substantial degradation thereof during any burn-in and/or testing process is minimal so that the silane layer 2 promotes a sufficient wetting effect on the active surface 20 of the semiconductor die 12, the upper surface 18 of the substrate 10, or both.

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N THE CLAIMS:

A marked-up version of each of the presently amended claims, highlighting the changes thereto, follows:

3. (Amended) The method of claim 1, wherein said wetting agent layer includes a layer of [silane] silane-based material.

8. (Amended) The method according to claim 1, wherein said wetting agent layer comprises one of [glycidoxypropyltinethoxysilane] glycidoxypropyltrimethoxysilane and ethyltrimethoxysilane.

9. (Twice Amended) The method according to claim 1, wherein said applying said wetting agent layer comprises providing a material for increasing the surface tension to one of [said active surface and said top surface] said surface of said semiconductor device and said surface of said substrate for the application of an underfill material.

61. (Three Times Amended) The method according to claim 58, wherein said wetting agent layer comprises a silane-based material. [one of silane, glycidoxypropyltinethoxysilane, and ethyltrimethoxysilane.]

62. (Twice Amended) A method for attaching a semiconductor assembly, said method comprising:
providing a semiconductor device having an active surface, a first end, a second end, a first lateral side end and a second lateral side end;
providing a substrate having an upper surface, a first side wall, a second side wall, a first lateral side wall and a second lateral side wall;
applying a [silane] silane-based material layer to one of a portion of said active surface of said

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semiconductor device and a portion of said upper surface of said substrate;
connecting said semiconductor device to said substrate so that said active surface of said
semiconductor device faces said upper surface of said substrate; and
applying an underfill material between said semiconductor device and said substrate.